The Mandible and Maxillary Stylets of *Scirtothrips citri* (Moulton) (Thysanoptera: Thripidae)

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Abstract.—The external morphology of the mandible and maxillary stylets of *Scirtothrips citri* (Moulton) are examined with scanning electron microscopy. The morphology of the mandible concurs with recent studies on other Thysanoptera indicating that it punctures the substrate. A method for directional control of the maxillary stylets without engagement of the apices is discussed.

The unusual, asymmetrical mouthparts of Thysanoptera include two structures capable of piercing food. One is the left mandible modified into a stout, sharp piercing organ that is hollow but lacking an aperture. The second piercing structure is the maxillary stylets comprised of paired styliform lacineae interlocked into a single feeding tube (Mound 1971). Protracted only during feeding, both structures otherwise are retracted into a mouth cone at the ventral-caudal margin of the head. During feeding by phytophagous *Haplothrips verbasci* (Osborn), suborder Tubulifera, (Heming 1978) and *Limothrips cerealium* (Haliday), suborder Terebrantia, (Chisholm and Lewis 1984), the mandible punctures the leaf cuticle and epidermis, and the maxillary stylets penetrate the wound to transport the contents of underlying mesophyll cells to the hypopharynx.

One of the most serious arthropod pests of citrus in California is the citrus thrips, *Scirtothrips citri* (Moulton), a species of Thysanoptera (suborder Terebrantia) whose feeding damages foliage and scars fruit. Although Horton (1918) described fruit scarring as the cell walls of punctured cells forced outward by the growth of surrounding tissue, exactly how *S. citri* feeding causes scarring is not well understood. To better understand this process, the present study examines the external morphology of the mandible and maxillary stylets.

Materials and Methods

S. citri were collected from a navel orange grove at the University of California Lindcove Field Station near Exeter, California, and reared in a glasshouse on *Rhus laurina* Nuttal seedlings (Tanigoshi and Nishio-Wong 1981). Voucher specimens were deposited in the Entomology Museum, University of California, Riverside.

First instar, second instar, and adult female mandible and maxillary stylets were protracted by modifying the method of Milne and Manicom (1978). A specimen container was constructed by cutting the pyramidal end from a #00 tissue embedding capsule (Electron Microscopy Sciences, Ft. Washington, PA) and covering both ends of the capsule with 102 μm polyester mesh (Tetco Inc., Elmsford, NY). The

fabric was held in place with capsule caps each with a hole slightly smaller than their diameter to permit adding and withdrawing fluid. Leaves infested with *S. citri* were agitated in 1% Liqui-Nox detergent (Scientific Products, Evanston, IL), and the immersed thrips were transferred by Pasteur pipette into the specimen container. After the container dried and the enclosed thrips were moving, it was filled with amyl acetate to induce mouthpart protraction. After standing for 30 min, the container was immersed in 1% Liqui-Nox solution to remove residual amyl acetate. The thrips were dehydrated in progressive concentrations of ethanol, critical-point dried in carbon dioxide, and sputter coated with gold. Specimens were examined with a JEOL JSM-35C scanning electron microscope and photographed with Polaroid Type 55 Positive-Negative Film. Mandible and maxillary stylet dimensions were measured on the photographs and divided by the photographic magnification to convert to actual size. Because amyl acetate induced differing amounts of mandible and maxillary stylet protraction, only the maximum dimensions observed in each life stage are presented.

RESULTS AND DISCUSSION

Surrounding the mandible and maxillary stylets, the mouth cone is comprised of the cephal labrum, caudal labium, and lateral paraglossae covered apically with sensilla (Fig. 1). Beneath the paraglossae the mandible and maxillary stylets pass through the labral ring (Fig. 1). During feeding by *L. cerealium*, the paraglossae move laterad and the labral ring is placed against the substrate (Chisholm and Lewis 1984). Oral papillae (Milne and Manicom 1978) are visible caudal to the labral ring (Fig. 1).

Immersion in amyl acetate ineffectively induced mouthpart protraction, and the maxillary stylets were more often protracted than the mandible. Of the 230 specimens examined, five protracted both the mandible and stylets, 13 protracted only the stylets, and two protracted only the mandible. Although the maxillary stylets of Thysanoptera are protracted by direct muscular action (Matsuda 1965), the mandible of *L. cerealium* is fused to the exoskeleton and protraction occurs only by contracting muscles that compress the mouth cone (Chisholm and Lewis 1984). If the mandible of *S. citri* is similarly fused, this may explain the lesser success of inducing mandible protraction.

In all life stages examined, the mandible is a stout cylinder tapering to a point (Figs. 3–5) suggesting that it punctures plant tissue as observed in *H. verbasci* (Heming 1978) and *L. cerealium* (Chisholm and Lewis 1984). A puncturing rather than rasping (Metcalf et al. 1962) mode of action agrees with the leakproof feeding punctures observed when *S. citri* was fed through an artificial membrane (Wiesenborn and Morse 1985). The greatest length X diameter of the protracted mandible (and number of specimens measured) was 10.0 μm in first instars (2), 20.8 μm X 1.3 μm in second instars (2), and 14.8 μm X 1.4 μm in adult females (3).

The maxillary stylets are longitudinally grooved on the inner surface (Figs. 4 & 6) to interlock into a single piercing and sucking organ with a sub-apical aperture (Fig. 2). The greatest length X diameter of the protracted stylets (and number of specimens measured) was 32.8 μm X 1.0 μm in first instars (9), 34.5 μm X 1.3 μm in second instars (6), and 22.8 μm X 1.0 μm in adult females (3). An internal median ridge and asymmetrical circular indentations are visible on the inner surface of a single stylet at the feeding aperture (Fig. 6). Similar morphology of the feeding aperture in
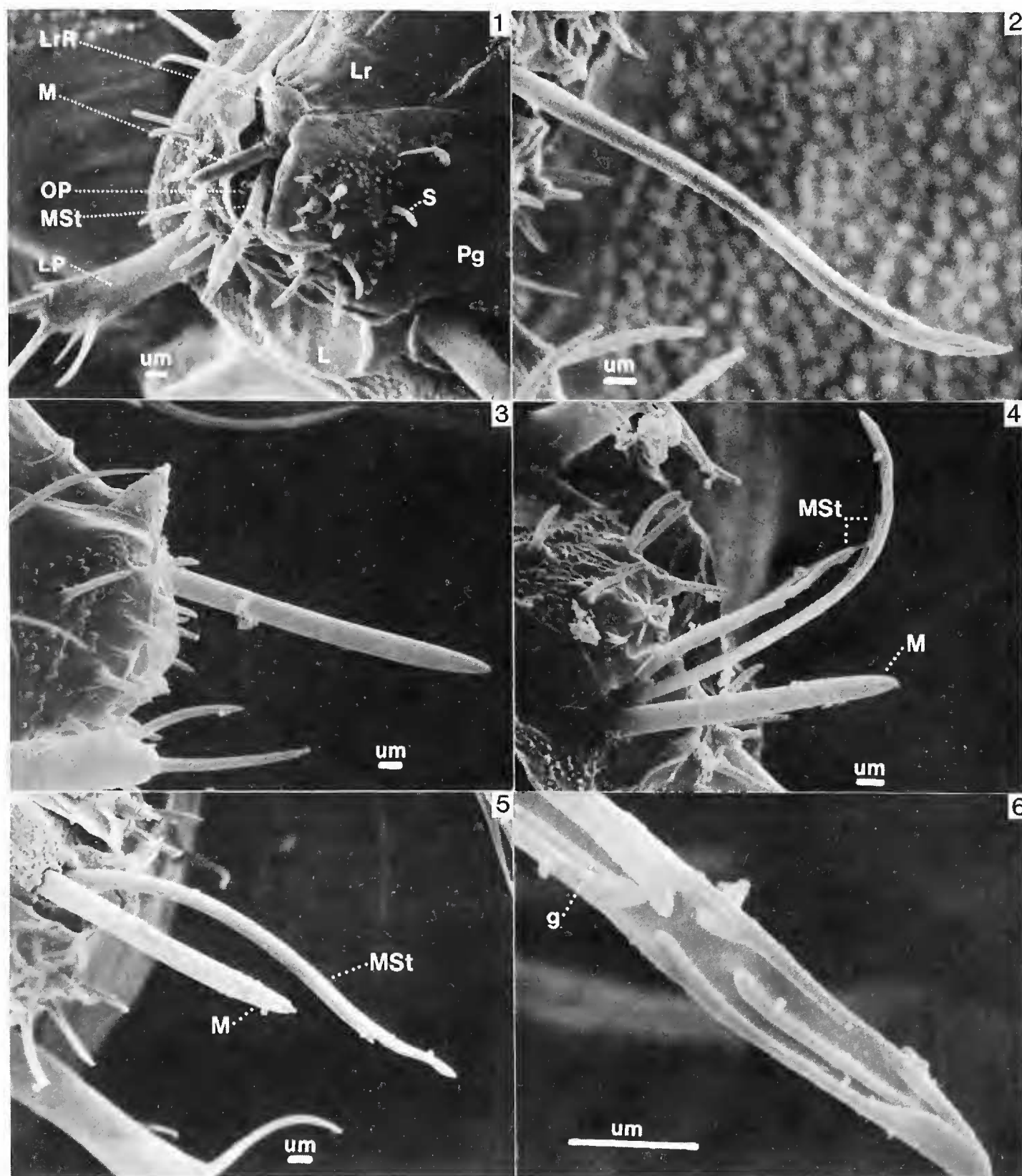
Figures 1–6. Scanning electron micrographs of *Scirtothrips citri* mouthparts: 1. First instar, ventral-lateral aspect of mouth cone showing labium (L), labial palp (LP), paraglossae (Pg), sensillum (S), labrum (Lr), labral ring (LrR), oral papillae (OP), mandible (M), and partially separated maxillary stylets (MSt). 2. First instar, interlocked maxillary stylets. 3. Second instar, lateral aspect of mandible. 4. Second instar, ventral aspect of mandible (M) and separated, unequally-protracted maxillary stylets (MSt). 5. Adult female, ventral aspect of mandible (M) and interlocked maxillary stylets (MSt) with one stylet protracted slightly beyond the other. 6. Adult female, inner surface of a single maxillary stylet at the apex showing the groove (g) that interlocks with the opposite stylet.

Scirtothrips aurantii Faure (Milne and Manicom 1978) supports its congeneric ranking with *S. citri.*

Heming (1978) found in *H. verbasci* that the apex of one maxillary stylet was held within a socket at the apex of the other. He hypothesized that stylet tip engagement

would cause the interlocked stylets to bend if either set of left or right style protractor muscles contracted more than the other. In contrast, Chisholm and Lewis (1984) suggested that the stylet apices of *L. cerealium* are less complex than in the Tubulifera and do not engage, allowing either stylet to protract beyond the other. In *S. citri,* the morphology of the stylets near the apex appear intermediate in complexity between *H. verbasci* and *L. cerealium,* and a socket as described in *H. verbasci* is not present. However, Heming described the movement of the maxillary stylets of *H. verbasci* as a "jabbing-whipping motion," movement we also have observed in *S. citri* feeding through an artificial membrane. Therefore, engagement of the apices may not be required for the maxillary stylets to bend by differences in muscle tension. Instead, directional control of the stylets may be similar to that proposed for the phytophagous Hemiptera (Pollard 1969), whereby the proximal portion of each maxillary stylet is flexible, and the distal portion is rigid and curved inwards. Protraction of one stylet beyond the other initiates bending toward the shorter stylet. When the shorter stylet is then equally protracted, support from the plant tissue guides it along the same curved path. In this manner, different plant cells at the same depth can be evacuated from a single entry site on the leaf surface, an ability that Chisholm and Lewis (1984) observed in *L. cerealium.* In *S. citri,* a separated maxillary stylet protracted beyond the other stylet is seen to curve inward (Fig. 4) concurring with Pollard's hypothesis. In our observations of *S. citri* feeding, the rapid swinging of the paired stylets may have been due to their sliding alternately past each other. Examination of stylet movement into plant tissue or an artificial substrate (e.g., agar) would help to substantiate that the method of maxillary stylet movement proposed for phytophagous Hemiptera also applies to terebrantian Thysanoptera.

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